

Projects 1-4 : Meso and submesoscale processes & modelling

Julien Le Sommer, IGE, CNRS / UGA

1. Overall purpose and articulation of the projects
2. Brief summary of projects activities and objectives
3. Highlight illustrations of some key activities.
4. Concluding remarks.

Overall purpose and articulations

- P1** ▶ Project #1. **Qiu / Chen / Nakano / Klein / Sasaki (US)**
« Exploring new upper ocean circulation dynamics : synergy SWOT/GCM/ADCP »
- P2** ▶ Project #2. **Le Sommer/Cosme (MEOM group @ IGE) (FR)**
« Modelling and data-assimilation: preparing the inversion of SWOT data »
- P3** ▶ Project #3. **Samelson/Chelton/Farrar/Molemaker (US)**
« Ocean mesoscale, sub-mesoscale, and internal wave variability »
- P4** ▶ Project #4. **Abernathey/Keating/Lachkar/Levy/Smith (US)**
« Fluxes at SWOT scales »

Overall purpose and articulations

▸ SWOT mission objectives : ocean

- estimating fluxes due to scale $< 100\text{km}$
- document energy cascades across scales $< 100\text{km}$
- infer vertical exchanges between surface / interior

Meeting these objectives will require

maps of SSH and maps of surface currents and their gradients
methods for inferring internal dynamics from surface observations

➔ 2D « inversion » of SWOT data, 3D « inversion » of SWOT data

model-based reconstruction

data-assimilation in
circulation models

⋮

data-oriented inversion methods

eg 2D : dynamic interpolation
3D : eSQG reconstruction

A range of inversion techniques of varying complexity will be used for inferring lateral/vertical exchanges from SWOT data

Overall purpose and articulations

General approach of the 4 projects:

- ❖ models / obs. inform on the actual dynamics that SWOT will sample (balance, scales...)
- ❖ models : realizations of ocean dynamics that can be used for developing inversion algorithms

- ▶ performing or using basin-scale **high resolution modeling**P1, P2, P3
- ▶ **assessment** of fine scales in high resolution models wrt obs.P1, P2
- ▶ **near geostrophic dynamics** and fluxes in models and obs.P1, P2, P3, P4
- ▶ **reconstruction of 2D** maps / lateral fluxes from SWOTP1, P2, P4
- ▶ **reconstruction** of 3D fields / vertical fluxes from SWOTP1, P2, P3, P4
- ▶ characterization and filtering of **internal wave SSH signals**P1, P2
- ▶ representation of **SWOT errors** for the inversion of SWOT dataP2

1. Overall purpose and articulation of the projects
2. **Brief summary of projects activities and objectives**
3. Highlight illustrations of some key activities.
4. Concluding remarks.

A brief summary of projects activities and objectives

PI : "Exploring new upper ocean dynamics : SWOT/GCM/ADCP"

Qiu / Chen / Nakano / Klein / Sasaki

- ▶ evaluating spatio-temporal **variability of SSH and surface velocity** signals from high-resolution **OGCMs** ($1/30^\circ$ OFES & $1/48^\circ$ ECCO2) and repeat ADCP measurements.
- ▶ Explore observability/**reconstructability of upper ocean circulation** by combining OGCM output and the SWOT Simulator.
- ▶ Improve **2D SSH mapping** with use of statistical & dynamical approaches.
- ▶ Advance our understanding of new upper ocean dynamics at $O(5-200\text{km})$ scales by analyzing high-resolution OGCM output and ADCP data, with the goal to maximize SWOT's scientific return.

Focus region : (eastern) North Pacific Ocean

A brief summary of projects activities and objectives

P2 : "Modelling and DA: preparing the inversion of SWOT data"

Le Sommer/Cosme/MEOM group

- ▶ basin-scale, realistic, sub-mesoscale permitting **model simulations**
- ▶ **Assessing** resolved **fine scales** with observations (campaigns, altimetry)
- ▶ **dynamical regimes** that SWOT will sample and mid/high latitudes
- ▶ dissemination of **virtual scenes** for testing inversion techniques
- ▶ innovative **inversion and data assimilation** techniques for SWOT

Focus region : North Atlantic ocean (20°N/70°N) / subpolar gyre

A brief summary of projects activities and objectives

P3 : "Ocean mesoscale, sub-mesoscale, and internal wave variability"

Samelson/Chelton/Farrar/Molemaker

- ▶ Characterizing and filtering/isolating internal wave SSH signals
- ▶ Estimation of mesoscale and sub-mesoscale horizontal velocity, vorticity and vertical velocity
- ▶ Mesoscale and sub-mesoscale near-geostrophic dynamics

Objective : to estimate quantitatively the new SSH signal variance that will be resolved by SWOT and the apportionment of this variance between near-geostrophic mesoscale/sub-mesoscale, internal wave, and other variability, and to determine the associated geographic and regime dependences

Focus region : California current system + other regions

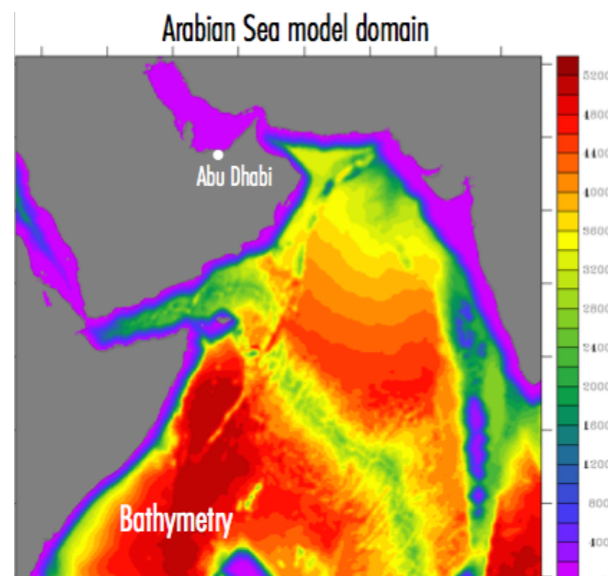
A brief summary of projects activities and objectives

P4 : "Fluxes at SWOT-scales"

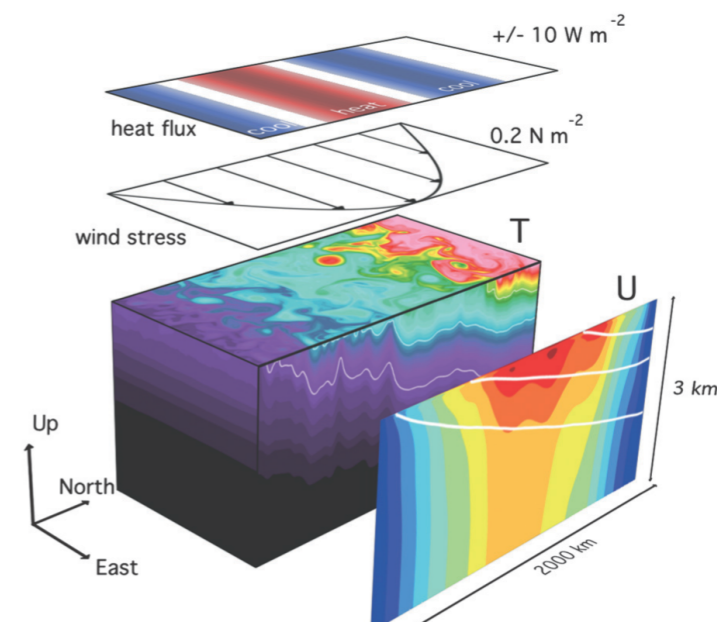
Abernathy/Keating/Lachkar/Levy/Smith

- ▶ Investigate statistics of surface submesoscale lateral/vertical fluxes of tracers (e.g. C_{anth} , O_2) in high-resolution simulations
- ▶ Develop/refine methods to estimate fluxes from observed surface data (PV-based and subgrid stochastic)
- ▶ Focus on 2 semi-idealized simulations with 1 km resolution, with BGC tracers. Measure fluxes and estimate from surface fields.

Arabian Sea — largest O_2 min zone



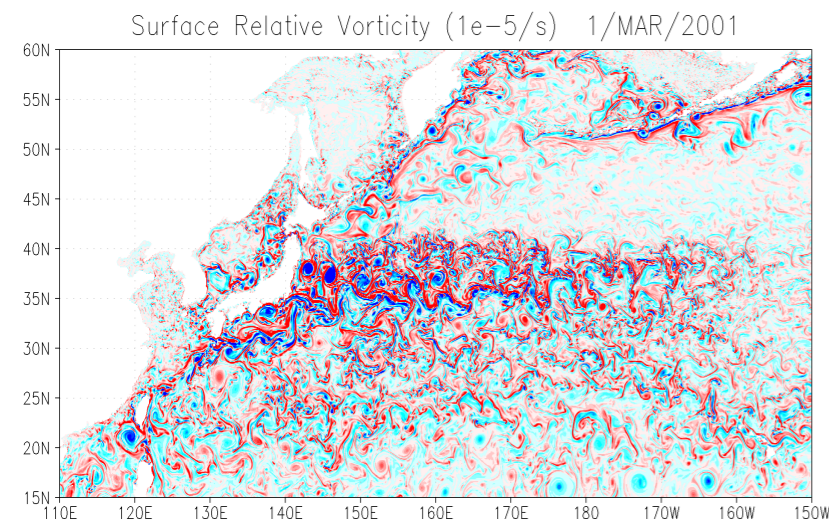
ACC — important sink for C_{anth}



1. Overall purpose and articulation of the projects
2. Brief summary of projects activities and objectives
3. Highlight illustrations of some key activities.
4. Concluding remarks.

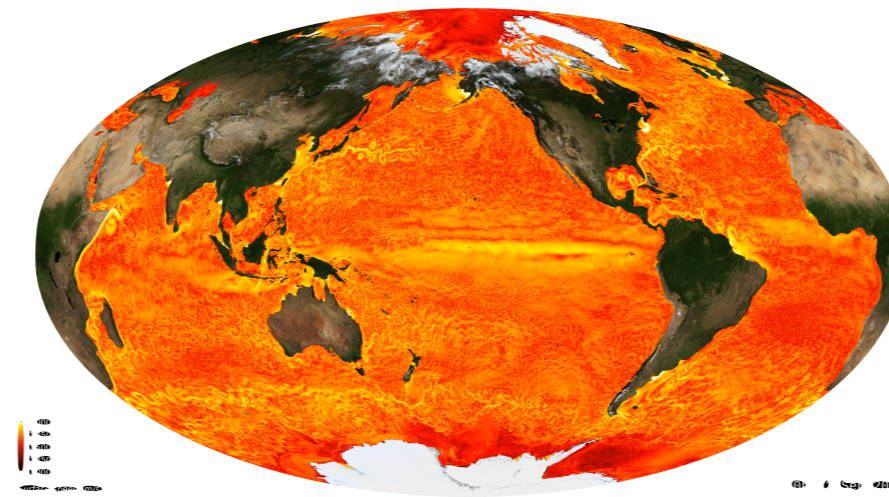
(Basin-to-global scale) High resolution ocean modeling

Models



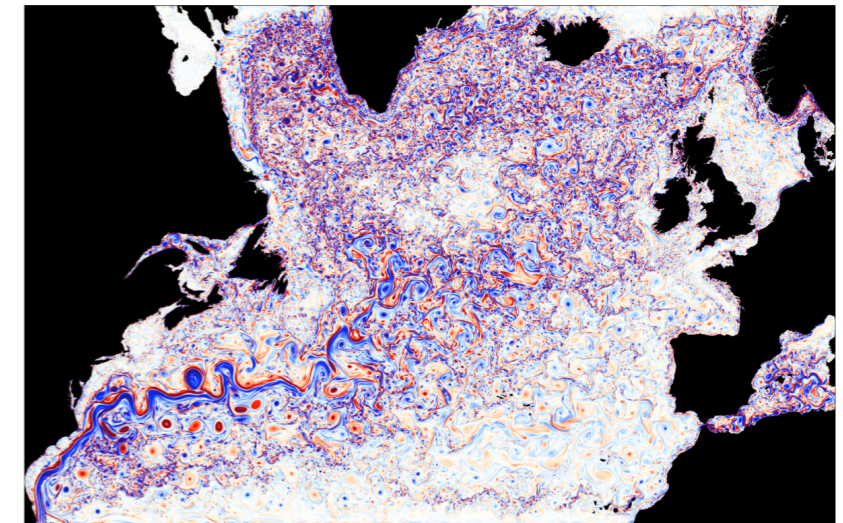
(JAMSTEC, OFES, $1/30^\circ$)

North Pacific



(NASA/JPL, MITGCM $1/48^\circ$)

Global

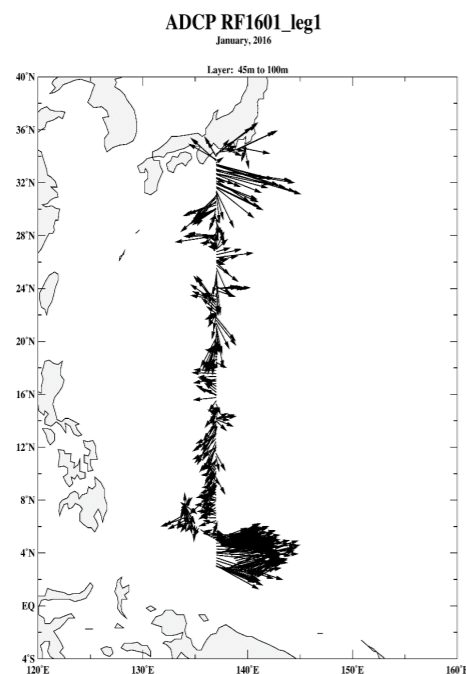


(MEOM, NEMO $1/60^\circ$ - 300 lev)

North Atlantic

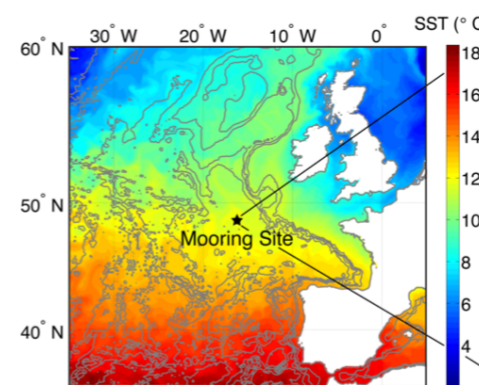
<http://meom-group.github.io/swot-natl60/>

Evaluated against observations



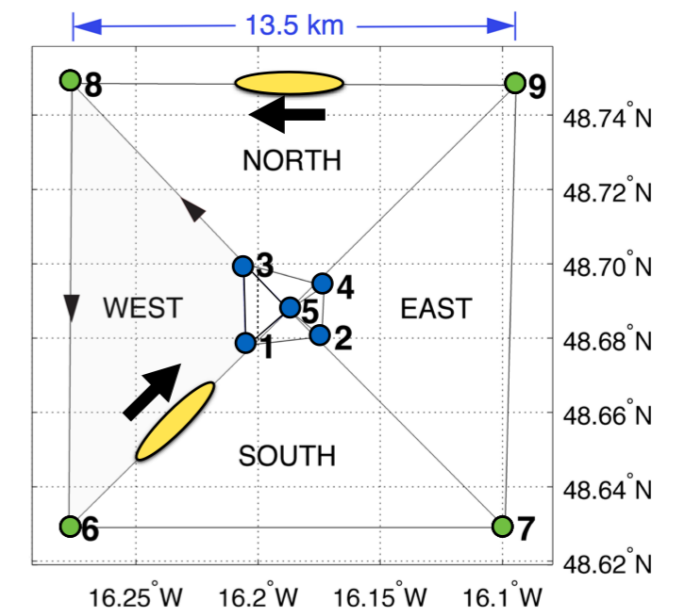
ADCP data

P1



(A. Naveira Garabato)

OSMOSIS array



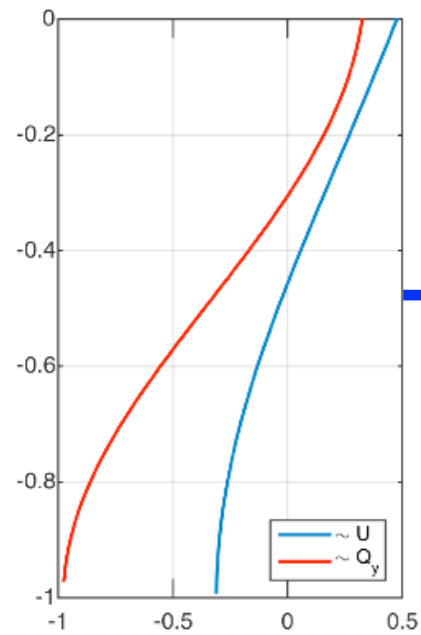
P2

Reconstruction of 3D fields from surface data

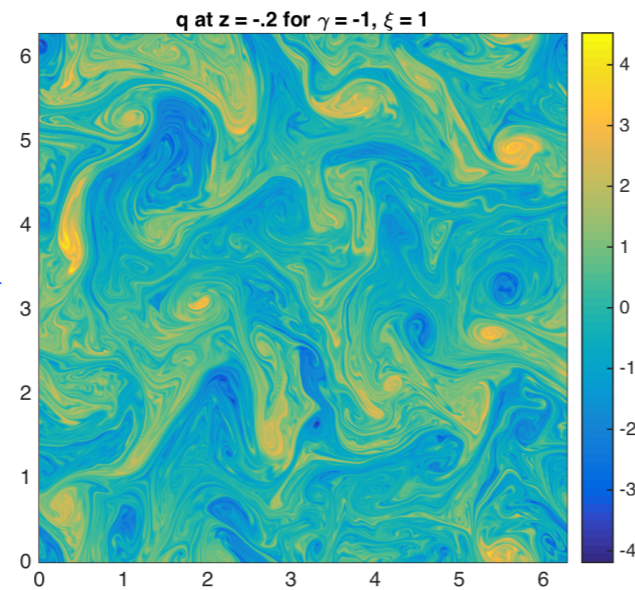
- Use SSH and SST in QG PV inversion to infer flow at depth.

P4

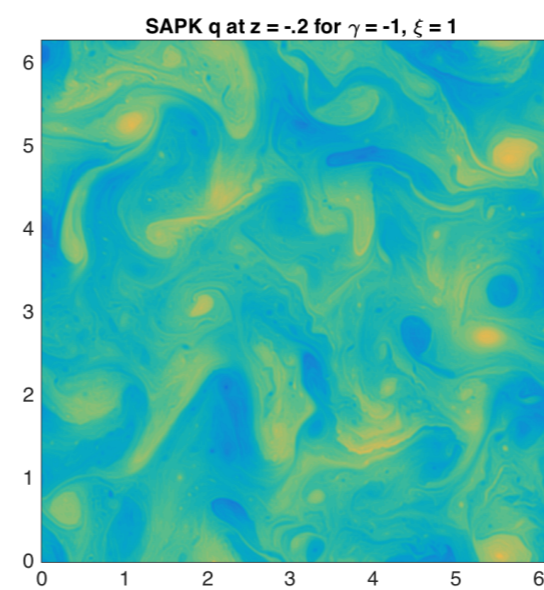
BC unstable flow



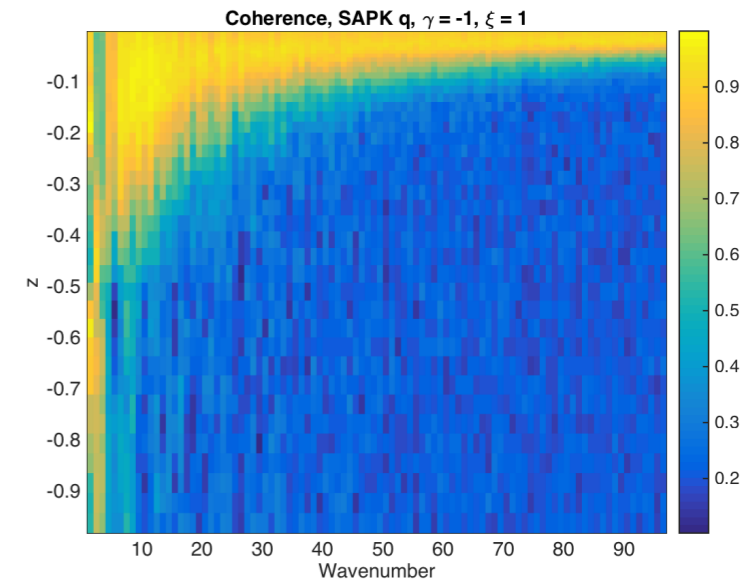
True PV(1000m)



Recon. PV(1000m)



Coherence = $f(z, k)$

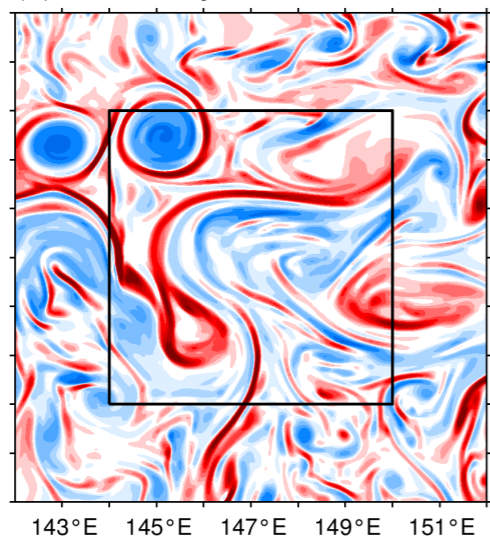


- Vertical velocity reconstructions based on eSQG framework

PI

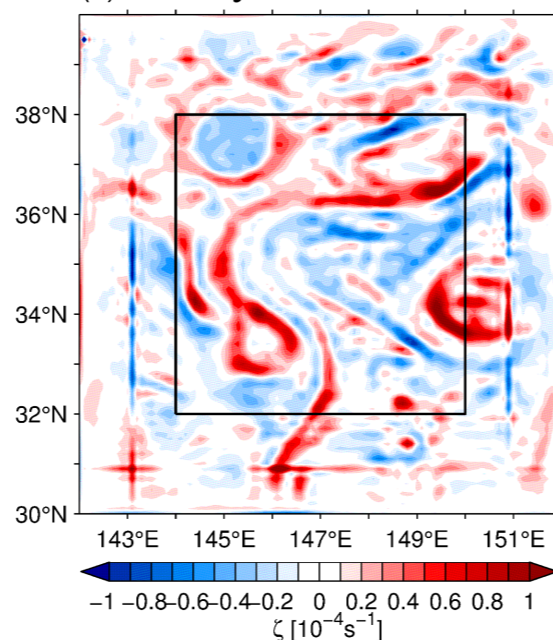
True vorticity

(b) OFES30 ζ at 2.5m



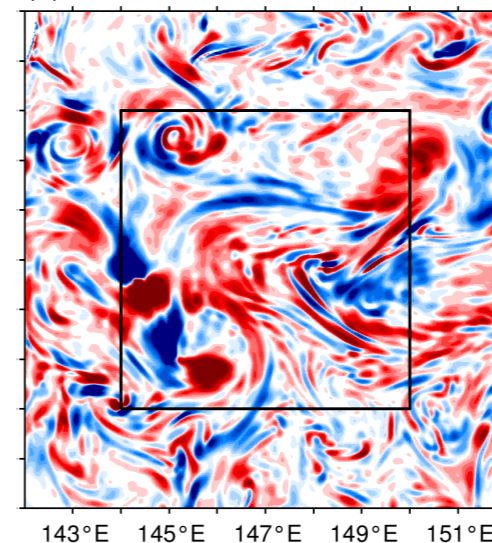
Recon. vorticity

(c) eSQG ζ at 5.0m



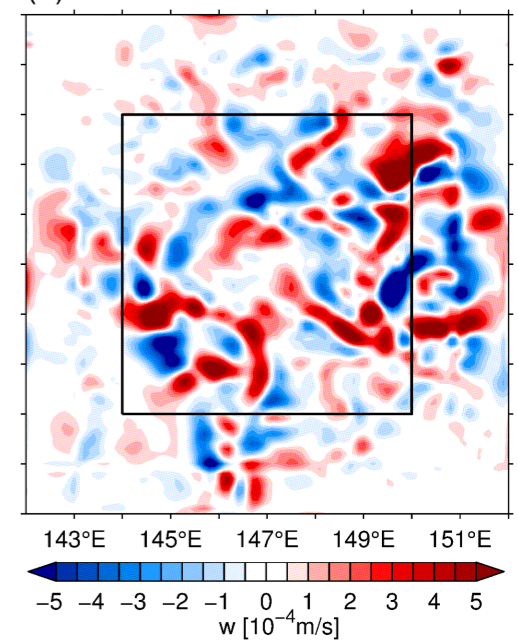
True w velocity

(c) OFES30 w at 199.5m



Recon. w

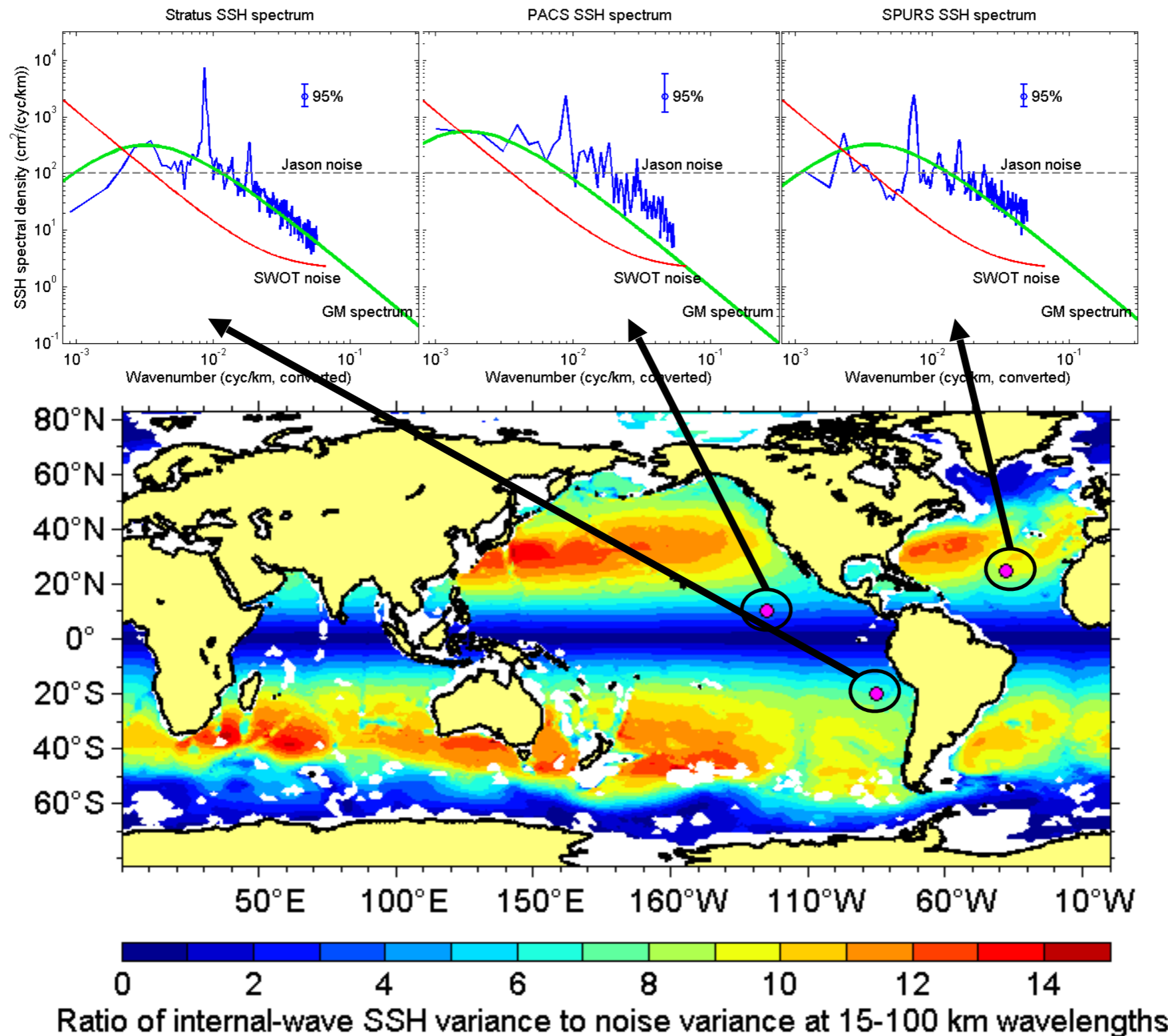
(d) eSQG w at 199.5m Correlation



Characterization of internal waves SSH signals

► Estimating the surface signature of internal waves

P3



see also P1

Description of SWOT errors for the inversion of SWOT data

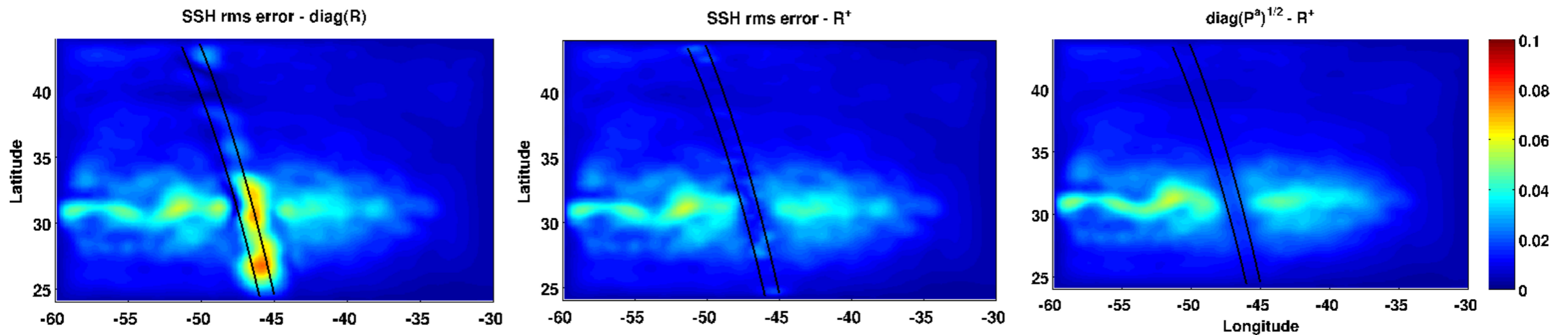
► spatially correlated errors

P2

neglecting spatial
correlation of errors

accounting for spatial
correlation of errors

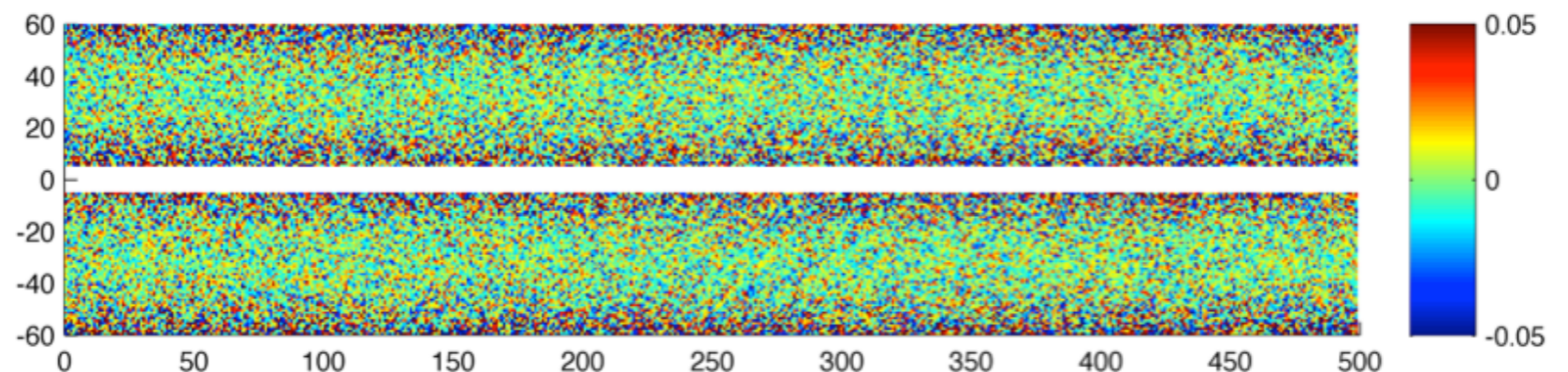
expected residual error



Residual SSH error after assimilation of SWOT data

► spatially uncorrelated errors

Example realization
of KaRIn noise



1. Overall purpose and articulation of the projects
2. Brief summary of projects activities and objectives
3. Highlight illustrations of some key activities.
4. Concluding remarks.

- ▶ Project #1. **Qiu / Chen / Nakano / Klein / Sasaki (US)**
« Exploring new upper ocean circulation dynamics : synergy SWOT/GCM/ADCP »
- ▶ Project #2. **Le Sommer/Cosme (MEOM group @ IGE) (FR)**
« Modelling and data-assimilation: preparing the inversion of SWOT data »
- ▶ Project #3. **Samelson/Chelton/Farrar/Molemaker (US)**
« Ocean mesoscale, sub-mesoscale, and internal wave variability »
- ▶ Project #4. **Abernathey/Keating/Lachkar/Levy/Smith (US)**
« Fluxes at SWOT scales »